Six-phase Fuzzy Control of City Single-cross Road

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Abstract. This paper discusses city single-cross road's traffic light real-control. Considering the pedestrians and non-motor vehicles, we carry on the six phase fuzzy control. It present a method of current phase green light delay , set up the algorithm and 3D controller design method. It also set up the principle of select control rule. This method was used to simulation research, the result is satisfactory.

1.Introduction

With the development of economy, the continuous increasing of urban modernization of traffic demand and traffic volume increased rapidly, the urban traffic network becomes more and more serious jam.Because the possibility of construction or expansion of the road in the city is smaller and smaller, so the optimization of signal timTing becomes the important measures to improve traffic conditions, therefore, many scholars at home and abroad put forward some solutions accordingly.First people established precise mathematical model .But even if the model is more complex , simulation are also in an ideal condition.It fit for less traffic situation in the city. But the modern city transportation system is a randomness and complex system affected by many factors . So precise mathematical model method often cannot conduct good control of traffic lights[2] .

This paper considers the intersection of a standard, on the premise of described earlier, six phase control of intersection are put forward.Because the more phase vehicle waiting time will be longer, and phase too little, the conflict is too much,easy to cause chaos. Experience shows six phase is the proper design, using the theory of figure of dyeing prove the point.The basis of reference [5] now continue with the captain for the green light phase delay metrics.But in phase control rules not only consider the captain,but also consider difference between it and the subsequent phase. This better catered to various aspects and has good practicability.

2. The ideas of signal light fuzzy control

Fuzzy control of the object can not be expressed in the exact mathematical model. But control rules only can be qualitative described in the form of a language. To realize fuzzy control, that is, people hope that through computer to complete the control activities described in natural language, which requires people devised a fuzzy controller according to the performance of the control law and system design.In order to design the fuzzy controller to realize the language control ,we must solve the design of the fuzzy control algorithm.Fuzzy control algorithm is designed to use fuzzy conditional statement, such as: if P then Q. If P or Q then S; If A, B, or C.Language variable values, generally has the following class, for example, positive (PL), positive middle (PM),positive small (PS), zero, negative small (NS) negative middle(NM), negative big (NL).And the output of the fuzzy inference machine is a fuzzy subset, it reflects different values of a combination of control language.If can only accept a control volume of the object, and this needs judging a control volume from the output of fuzzy subset. It is also designed a set from fuzzy set to normal mapping, and this mapping is called judgment.In this problem, $\Delta G = fc(G, L, \Delta L)$. G stand for current phase green light passing through time, L stand for current phase length , ΔG stand for green light delay.Fc is a three-dimensional fuzzy controller, G, L and ΔL is its input, ΔG is its output, its structure is shown in Fig.1.

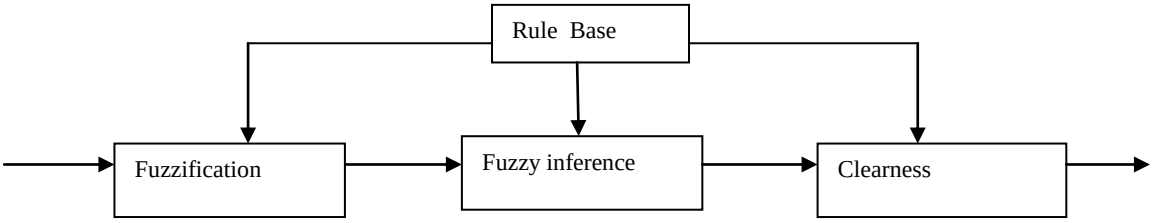

Figure 1. Structure chart

3. Six phase control algorithm of single-cross road

At intersection must make the different directions of traffic flow, based on one direction, all directions of traffic flow is the sum of a passage of time is called a cycle.Each passage is called a phase.In general, each phase of the passage of time may not be less than 15 seconds in order to avoid the danger, but as a cycle should not exceed 200 seconds, otherwise the driver can't stand long time in mentally.Traffic control single cross the fork is on the chosen number of phase, for each phase distribution of green time, the vehicle can be smoothly through the intersection and make the arm length is the shortest in intersection.In reality, because there is no direct left through the intersection, pedestrians can be up to two straight to the left, turn right at any time.

And a non-motor vehicle lanes can turn right at any time, considering the needs of pedestrians and non-motor vehicles, we equipped with six phase to the intersection.In order not to disturb each other, each phase of the two direction should be equipped with at least one lane, this is shown in Fig. 2 below.

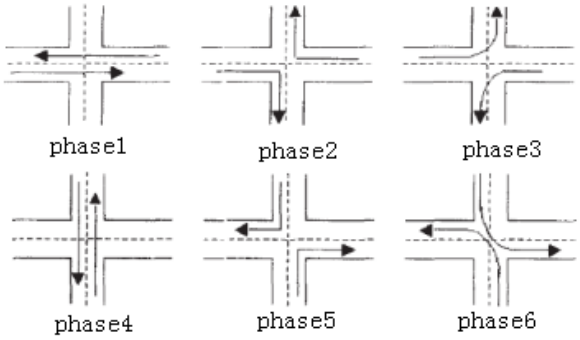

Figure 2. Intersection six phase diagram

Phase 1, 4, used in motor vehicles, non-motor vehicles and pedestrians. Phase 2, 5 used for motor vehicles.Phase 3, 6 used for non-motor vehicles and motor vehicle.

Suppose G stand for the current phase that has open green time, L stand for the current phase of the captain of the car, L ' stand for the current phase that the subsequent phase of the captain of the car, Δ L = L - L', Δ G stand for the current phase green light extension of time.

The following is six phase control algorithm for single cross road:

Step 1: starting from the reference phase, first specified six aspect minimum and maximum distribution of green light time Gmin, Gmax ;

Step 2: assign the current phase minimum green light time G = Δ G = Gmin;

Step 3: measure Δ G in the current phase of the queue length L, the subsequent phase of queue length L ', calculate the Δ L;

Step 4: if L = 0 or G + Δ G = Gma x, then turn right of way on to the next phase, return to step 2, otherwise, continue;

Step 5: according to G, L and Δ G value, according to the fuzzy controller is decided to the current phase of the green light time delay Δ G, if G + Δ G > = Gmax ,then Δ G = Gmax - G, and transfer passage to the subsequent phase, return to step 2, otherwise G = G + Δ G, return to step 3.

4. Design of fuzzy controller

Know that by the algorithm: requires three fuzzy input G, L, Δ L and a fuzzy output Δ G, G language value is defined as very long, long, middle, short, and very short;L language set for very long, long, medium, short, and very short ； ΔL language value is defined as a plus big, plus middle, zero, negative middle, and negative big;Δ G language value is defined as very long, long, middle, short and very short.The following is a specific assignment, [0, 1] between the value of the number representation theory field belongs to the membership degree of each language value.

Table 1. G language evaluation

Domain / Language	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
Very short	1	1	.9	.6	.3										
short			.3	.8	1	.9	.7								
middle					.3	.8	1	.9	.7						
long							.3	.8	1	.9	.7				
Very long										.3	.6	.9	1	1	

Table 2. L language evaluation

Domain / Language	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Very short	.9	1	.9	.7	.5	.3	.1													
Short	.1	.3	.5	.7	.9	1	.9	.7	.5	.3	.1									
Middle				.1	.3	.5	.7	.9	1	.9	.5	.3	.1							
Long												1	.3	.7	.9	1	.9	.5	.3	.1
Very long															.1	.3	.5	.7	.9	1

Table 3. ΔL language evaluation

Domain / Language	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Negative big	1	.9	.7	.5	.3	.1															
Negative middle	.1	.3	.5	.7	.9	1	.9	.7	.5	.3	.1										
Zero					.1	.3	.7	.9	1	.9	.7	.5	.3	.1							
Plus middle									.1	.3	.5	.7	.9	1	.9	.7	.5	.3	.1		
Plus big													.1	.3	.5	.7	.9	1			

Table 4. ΔG language evaluation

Domain / Language	3	6	9	12	15	18	21	24	27	30	33	36	39	42
Very short	.9	1	.9	.7	.5	.3	.1							
Short	.3	.5	.7	.9	1	.9	.7	.5	.3					
Middle			.3	.5	.7	.9	1	.9	.5	.3				
Long							.3	.7	.9	1	.9	.5	.3	
Very long									.5	.7	.9	1		

For general n Input m output fuzzy system, the form of fuzzy rules is followed:
Rk:If(x1 is A1k)and (x2 is A2k)and …and (xn is Ank)Then (y1 is B1k)… and (ym is BMk). One fairly Rk rule, said the first k {xi} (I = 1,..., n) is the n input, {yj} (j = 1,..., m) is m output, Aik, Ajk are defined on the input variable and output variable fuzzy sets.Although in a fuzzy system, the system is not consistent with each other control rules were considered without strict requirements, but in practice, the unreasonable rules may bring about the decrease of system intelligence, here are several ways:

（1）The same conditions, but the conclusion is inconsistent

R1:If x1 is A1 and x2 is A2 then y is Positive Large.
R2:If x1 is A1 and x2 is A2 then y is Negative Large.

（2）Part of the form different, but essentially is consistent, and conclusion is inconsistent

R1:If x1 is A1 and x2 is A2 then y is Positive Large.
R2:If x1 is A1 and x3 is A3 then y is Negative Large.

Although the x2 is A2 and x3 is A3 form, but may say the same conditions, the weather was very hot means a high temperature

（3）Conditions may contradict each other

If the sun is bright and the rain is heavy.

（4）If there are a number of conclusions, there may be a contradiction between the conclusion

If x is A then y is B and z is C.But y is B and z is C is contradiction.

Paper gives a three input single output fuzzy system, based on the above principle, the control rule, and you get 76 form.

If G is very long and L is middle and ΔL is very short then ΔG is middle.

According to the state of the three input parameters, the fuzzy control rules determine the final green light time delay time .Actually each control statements R is defined in G * L * Δ L * Δ G on the fuzzy relation, membership degree:

$uR(g,l,\Delta l,\Delta g)=\min\{uG(g),uL(l),u\Delta L(\Delta l),u\Delta G(\Delta g)\}$

Finally, the fuzzy statement for each R, S,... The final membership is:

$Uc(g,l,\Delta l,\Delta g)=\max\{ uR(g,l,\Delta l,\Delta g), us(g,l,\Delta l,\Delta g),\ldots\}$

Then we can adopt vague operation, the maximum membership degree method or the weighted average method can be used.

5. Simulation study

Paper is in collaboration with Linyi traffic police, is part of Linyi city open project.It has been formed software, through the identification and is ready to be put into use.The author wrote the computer simulation program in Visual Basic 6.0, through the computer simulation we found stranded vehicles less in a single intersection , the result is satisfactory.This is visible that the fuzzy control method can control the traffic intersection signal better.

Table 5. simulation result

	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
Waiting vehicle sum	41	50	44	56	52
Pass through vehicle sum	33	42	35	46	43
Average pass through rate	80%	84%	80%	82%	83%

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